Remarks

The Final Office Action dated 6 September 2002 has been received and reviewed. Claims 76-88 have been added. Claims 46, 51, 53, and 55 have been amended. And claims 47-50 have been cancelled. The pending claims are claims 46 and 51-88. Reconsideration and withdrawal of the rejections are respectfully requested.

Claim Amendments

Claim 46 was amended to substantially include all of the elements of original claim 50.

Claims 51, 53, and 55 were amended to properly reflect their dependency from claim 46.

New claim 76 substantially includes all of the elements of original claims 46 and 47.

New claims 77-78 substantially include all of the elements of original claims 48 and 49 respectively.

New claims 79-88 are original claims 50-59 rewritten to ultimately depend from new claim 76.

No new matter was added.

Double Patenting Rejection

Claims 46-75 were rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-42 of U.S. Patent No. 6,074,960. Submitted herewith is a Terminal Disclaimer which, Applicants submit, is in compliance with 37 C.F.R. § 1.321(c) and thereby obviates the Examiner's double patenting rejection of pending claims 46-75.

Allowed Claims

Applicants acknowledge that claims 68-75 are allowed.

Objected to Claims

Applicants acknowledge that claims 47-49 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. In response, Applicants have added new claim 76, which substantially includes all of the elements of original claim 47, rewritten in independent form. Applicants have also added new claims 77-78, which substantially include all of the elements of claims 48-49 respectively, and new claims 79-88, which are original claims 50-59 rewritten to ultimately depend from new claim 76. Applicants submit that claims 76-88 are in allowable form.

I. **Whether claims 46 and 57 are patentable under 35 U.S.C. § 103(a) over Hayashi et al.**

The Examiner rejected claims 46 and 57 under 35 U.S.C. § 103(a) as being unpatentable over Hayashi et al. (U.S. Patent No. 5,482,895). Applicants traverse this rejection. However, to further move this case towards issuance, Applicants have amended claim 46 to recite that the solution includes a mineral acid and a peroxide. As amended, Applicants submit that claims 46 and 57 are not *prima facie* obvious for at least the following reasons.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art references must teach or suggest all the claim limitations. *See* M.P.E.P. § 2143.

Applicants submit that claims 46 and 57 are not *prima facie* obvious because Hayashi et al. does not teach or suggest all of the elements of such claims. For example, claim 46 recites selectively etching a portion of the metal nitride region against the cobalt silicide region using a solution including a mineral acid and a peroxide, where the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute. In

contrast to claim 46, Hayashi et al. does not teach an etch rate for selectively etching metal nitride against cobalt silicide. In fact, Hayashi et al. is silent as to etch rates of various disclosed solutions. "Silence in a reference is hardly a proper substitute for an adequate disclosure of facts from which a conclusion of obviousness may justifiably follow." *In re Burt and Walter*, 148 U.S.P.Q. 548, 553 (C.C.P.A. 1966).

Further, claim 46 recites that the solution includes a mineral acid and a peroxide. In contrast, Hayashi et al. teaches removing titanium nitride film using a mixed liquid of $NH_4OH+H_2O_2$. Hayashi et al. does not teach removing metal nitride using a solution that includes a mineral acid. Therefore, Hayashi et al. does not teach all of the elements of claim 46.

Claim 57, which depends from claim 46, is not *prima facie* obvious for the same reasons as presented above in regard to claim 46. In addition, claim 57 recites additional elements that further support patentability when combined with claim 46.

For at least the above reasons, Applicants submit that claims 46 and 57 are not *prima facie* obvious in view of Hayashi et al. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

II. Whether claims 50-56 and 58-59 are patentable under 35 U.S.C. § 103(a) over Hayashi et al. in view of Berti et al.

The Examiner rejected claims 50-56 and 58-59 under 35 U.S.C. § 103(a) as being unpatentable over Hayashi et al. as applied to claim 46 above, and further in view of Berti et al. (U.S. Patent No. 5,567,651).

Applicants traverse this rejection and submit that claims 50-56 and 58-59 are not *prima facie* obvious because the combination of Hayashi et al. and Berti et al. does not teach or suggest all of the elements of such claims. Further, Applicants have amended claim 46 to substantially include all of the elements of original claim 50. Applicants submit that claim 46 is also not *prima facie* obvious in view of the combination of Hayashi et al. and Berti et al.

For example, claims 50-56 and 58-59, which depend, either directly or ultimately, from claim 46, include all of the elements of claims 46. As such, claims 50-56 and 58-59 include a

solution that etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute. As stated above, Hayashi et al. is silent regarding etch rates. The addition of Berti et al. does nothing to correct this deficiency already present in Hayashi et al.

In fact, Berti et al. teaches away from the present invention. For example, Berti et al. teaches removing unwanted cobalt and titanium nitride by immersing the wafer for 30 minutes in a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. The thickness of the titanium nitride layer prior to silicidation is 50 to 150 Å. *See* Berti et al., column 3, lines 24-26. Therefore, the etch rate of the titanium nitride as taught by Berti et al. is 1.66 Å/minute for a 50 Å layer to 5 Å/minute for a 150 Å layer. Claim 46, on the other hand, recites etch rates of about 50 Å/minute to about 150 Å/minute for the metal nitride region, which are much faster rates than those taught by Berti et al. As such, the combination of Hayashi et al. and Berti et al. does not teach or suggest all of the elements of claims 50-56 and 58-59.

In addition, claims 50-56 and 58-59 recite additional elements that further support patentability when combined with claim 46. For example, claim 53 recites that the solution includes a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water). As admitted by the Examiner, neither Hayashi et al. nor Berti et al. teaches solutions that include deionized water. However, the Examiner alleged that it would have been obvious to one of skill in the art to dilute the solution with an appropriate amount of deionized water, creating a concentration of mineral acid and peroxide that would optimize the removing process of metal nitride and cobalt against the cobalt silicide. Applicants traverse this allegation and submit that Berti et al. teaches away from this alleged motivation.

As state above, Berti et al. teaches an etch rate for titanium nitride of 1.66 Å/minute to 5 Å/minute. This etch rate is much slower than the etch rate recited by claim 46 (from which claim 53 depends). Diluting the solution taught by Berti et al. with deionized water, as is suggested by the Examiner, would cause the etch rate for titanium nitride to decrease, thereby becoming even further slower than the etch rate recited in claim 46. Therefore, one skilled in the

art would not be motivated to dilute the solution taught by Berti et al. to produce the present invention.

In the Response to Arguments, the Examiner failed to address Applicants' assertion that Berti et al. teaches away from the present invention by disclosing much slower etch rates than those recited in claims 50-56 and 58-59. Further, the Examiner failed to address the assertion that Berti et al. teaches away from being used to modify Hayashi et al. in the manner alleged by the Examiner.

For at least the above reasons, Applicants submit that claims 50-56 and 58-59 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

III. Whether claims 60-67 are patentable under 35 U.S.C. § 103(a) over Wei et al. in view of Berti et al.

The Examiner rejected claims 60-67 under 35 U.S.C. § 103(a) as being unpatentable over Wei et al. (U.S. Patent No. 5,047,367) in view of Berti et al.

Applicants traverse this rejection and submit that claims 60-67 are not *prima facie* obvious because the combination of Wei et al. and Berti et al. does not teach or suggest all of the elements of claims 60-67.

For example, claim 60 recites selectively etching the cobalt region against the metal nitride region using a solution including a mineral acid and a peroxide. In contrast to claim 60, Wei et al. teaches etching cobalt using a mixture of nitric acid and water. *See* Wei et al., column 7, lines 58-60. In other words, Wei et al. does not teach selectively etching cobalt against metal nitride using a solution including a mineral acid and a peroxide as is recited in claim 60.

The addition of Berti et al. does nothing to cure this deficiency already present in Wei et al. For example, Berti et al. teaches simultaneously etching the unwanted cobalt and titanium nitride using a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. Unlike claim 60, Berti et al. does not teach selectively etching the cobalt region against the metal nitride region. In other words, Berti et al. teaches away from claim 60 by disclosing a mixture

including hydrogen peroxide that simultaneously etches cobalt and titanium nitride. A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc v. Garlock, Inc.*, 220 U.S.P.Q. 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). Therefore, the combination of Wei et al. and Berti et al. does not teach or suggest all of the elements of claim 60.

Further, Applicants submit that there is no suggestion or motivation to combine Wei et al. with Berti et al. to produce the present invention because Wei et al. teaches away from being combined with Berti et al. It is improper to combine references where the references teach away from their combination. *See In re Grasselli*, 218 U.S.P.Q. 769, 779 (Fed. Cir. 1983). For example, Wei et al. teaches forming a titanium layer on a silicon substrate. *See* Wei et al., column 3, lines 16-17. A conformal layer of cobalt is then formed on the titanium layer. *Id.* at column 3, lines 18-20. After depositing the titanium and cobalt, the substrate is annealed in a nitrogen or ammonia ambient, causing the titanium to diffuse upward through the cobalt to the surface, while the cobalt diffuses downward to the silicon surface where it reacts to form cobalt silicide. *Id.* at column 3, lines 21-29. At the surface, the titanium reacts with the nitrogen atmosphere to form titanium nitride. *Id.* at column 3, lines 34-36.

After the first anneal, Wei et al. teaches that an intermediate structure is formed (*see* FIG. 4) in those regions where the titanium layer and the cobalt layer overlie silicon (e.g., regions 23, 24, and 21 of FIG. 7). Following the first anneal, the intermediate structure (FIG. 7) is etched to remove the unreacted cobalt and the unreacted titanium. *Id.* at column 7, lines 57-58. The cobalt is etched using a mixture of nitric acid and water. The titanium is etched using a mixture of hydrogen peroxide, ammonium hydroxide, and water. *Id.* at column 7, lines 58-65. Wei et al. teaches that these etches are selective in that they remove all unreacted metal but do not etch the intermediate silicide/nitride structures. *Id.* at column 8, lines 1-4. In other words, the cobalt and titanium etches taught by Wei et al. do not etch the titanium nitride being formed at the surface of the structure.

Berti et al., on the other hand, teaches etching cobalt and titanium nitride at the same time using the same solution. Therefore, one skilled in the art would not be motivated to combine the

teachings of Wei et al. with Berti et al. because Wei et al. teaches etching cobalt and titanium without etching titanium nitride, while Berti et al. teaches etching both cobalt and titanium nitride simultaneously.

Claims 61-67, which depend, either directly or ultimately, from claim 60, are not *prima facie* obvious in view of the cited references for the same reasons as presented above for claim 60. In addition, claims 61-67 each recite additional elements that further support patentability when combined with claim 60.

For example, claim 62 recites that the mineral acid includes HCl. The combination of Wei et al. and Berti et al., on the other hand, does not teach a solution that includes HCl. Further, there is no suggestion or motivation in either reference that would lead one skilled in the art to add HCl to the solutions taught by either reference.

Further, for example, claim 64 teaches that the solution includes a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water). The combination of Wei et al. and Berti et al., on the other hand, does not teach or suggest such ratios. For example, as stated above, Wei et al. teaches etching cobalt using a mixture of nitric acid and water where the mixture is a ratio of approximately 1:1. In other words, Wei et al. does not teach a solution of mineral acid, peroxide, and deionized water in a ratio of 1:1:300 to about 1:1:70 as recited by claim 64.

The addition of Berti et al. does nothing to correct this deficiency already present in Wei et al. For example, Berti et al. teaches etching both cobalt and titanium nitride using a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. Berti et al. does not teach any ratios for the etching mixture. One skilled in the art would not be motivated to combine the teachings of Wei et al. and Berti et al. to produce the present invention because the two references teach completely different mixtures, and the references, either alone or in combination, do not teach the solutions and/or ratios recited by claim 64.

In addition, claim 66 recites that the cobalt region is selectively etched against the metal nitride region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute. In contrast to claim 66, Wei et al. does not teach any etch rates. Berti et al. teaches a cobalt layer having a

thickness of about 165-300 Å. Following silicidation, the unconsumed cobalt is removed using the above-mentioned mixture for 30 minutes. *See* Berti et al., column 3, lines 50-55. Even assuming that the unconsumed cobalt has a thickness equal to that of the original cobalt layer (160-300 Å), the etch rate taught by Berti et al. would equal 5.5 Å/minute to 10 Å/minute for cobalt. In other words, the etch rates taught by Berti et al. are much slower than the etch rates recited in claim 66. Because this combination of references does not teach all the elements of claim 66, such claim is not *prima facie* obvious in light thereof.

In the Response to Arguments, the Examiner failed to address several arguments submitted by Applicants in the previous Response and restated above. For example, the Examiner failed to address Applicants' argument that Wei et al. teaches away from being combined with Berti et al. Wei et al. teaches that the intermediate titanium nitride structure is not etched using either the mixture of nitric acid and water or the mixture of hydrogen peroxide, ammonium hydroxide, and water. *See* Wei et al., column 8, lines 1-4. Berti et al. teaches etching cobalt and titanium nitride at the same time using a mixture of phosphoric, acetic, and nitric acids and hydrogen peroxide. Applicants respectfully ask the Examiner why one skilled in the art would combine the mixtures taught by Wei et al. that do not etch titanium nitride with the solutions taught by Berti et al. that do etch titanium nitride. Absent any motivation or suggestion, Wei et al. cannot be combined with Berti et al. to produce the present invention.

For at least the above reasons, Applicants submit that claims 60-67 are not *prima facie* obvious in view of the cited references. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

Summary

It is respectfully submitted that the pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted for
Micron Technology, Inc.

By
Mueting, Raasch & Gebhardt, P.A.
P.O. Box 581415
Minneapolis, MN 55458-1415
Phone: (612) 305-1220
Facsimile: (612) 305-1228
Customer Number 26813

26813
PATENT TRADEMARK OFFICE

6 Nov 2002
Date

By: [signature]
Mark J. Gebhardt
Reg. No. 35,518
Direct Dial (612)305-1216

CERTIFICATE UNDER 37 C.F.R. § 1.8:
The undersigned hereby certifies that this paper is being transmitted by facsimile in accordance with 37 C.F.R. § 1.6(d) to the Patent and Trademark Office, addressed to Assistant Commissioner for Patents, Washington, D.C. 20231, on this 6th day of November, 2002, at 12:55pm (Central Time).

By: [signature]
Name: SARA E. OLSON

APPENDIX A - CLAIM AMENDMENTS INCLUDING NOTATIONS TO INDICATE CHANGES MADE
Serial No.: 10/050,639
Docket No.: 150.00560104

Amendments to the following are indicated by underlining what has been added and bracketing what has been deleted.

In the Claims

For convenience, all pending claims are shown below.

46. **(Once Amended)** An etching method for use in integrated circuit fabrication, the method comprising:

providing a substrate assembly comprising a metal nitride region and a cobalt silicide region; and

selectively etching a portion of the metal nitride region against the cobalt silicide region using a solution comprising a mineral acid and a peroxide, wherein the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute.

51. **(Once Amended)** The method according to claim [50]46, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H_2SO_4, H_3PO_4, HNO_3, and dilute HF.

52. The method according to claim 51, wherein the mineral acid comprises HCl.

53. **(Once Amended)** The method according to claim [50]46, wherein the solution comprises a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water).

54. The method according to claim 53, wherein the solution comprises a ratio in a range of about 1:1:25 (mineral acid:peroxide:deionized water) to about 1:1:10 (mineral acid:peroxide:deionized water).

55. **(Once Amended)** The method according to claim [50]46, wherein the solution comprises a ratio in a range of about 0.05:1:6 (mineral acid:peroxide:deionized water) to about 1:1:6 (mineral acid:peroxide:deionized water).

56. The method according to claim 55, wherein the solution comprises a ratio in a range of about 0.1:1:6 (mineral acid: peroxide:deionized water) to about 0.5:1:6 (mineral acid:peroxide:deionized water).

57. The method according to claim 46, wherein the peroxide comprises hydrogen peroxide.

58. The method according to claim 46, wherein the solution comprises a ratio in a range of about 1:50 (peroxide:deionized water) to about 1:1 (peroxide:deionized water).

59. The method according to claim 58, wherein the solution comprises a ratio in a range of about 1:10 (peroxide:deionized water) to about 1:5 (peroxide:deionized water).

60. An etching method for use in integrated circuit fabrication, the method comprising:

providing a substrate assembly comprising a metal nitride region and a cobalt region; and

selectively etching the cobalt region against the metal nitride region using a solution comprising a mineral acid and a peroxide.

61. The method according to claim 60, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H_2SO_4, H_3PO_4, HNO_3, and dilute HF.

62. The method according to claim 61, wherein the mineral acid comprises HCl.

63. The method according to claim 60, wherein the peroxide comprises hydrogen peroxide.

64. The method according to claim 60, wherein the solution comprises a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water).

65. The method according to claim 64, wherein the solution comprises a ratio in a range of about 1:1:200 (mineral acid:peroxide:deionized water) to about 1:1:100 (mineral acid:peroxide:deionized water).

66. The method according to claim 60, wherein selectively etching the cobalt region against the metal nitride region further comprises selectively etching the cobalt region against the metal nitride region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute.

67. The method according to claim 60, wherein selectively etching the cobalt region against the metal nitride region further comprises selectively etching the cobalt region against the metal nitride region at an etch rate in a range of about 100 Å/minute to about 200 Å/minute.

68. An etching method for use in integrated circuit fabrication, the method comprising:
providing a substrate assembly comprising a metal nitride region;
forming a cobalt region on a first portion of the metal nitride region;
forming a cobalt silicide region on a second portion of the metal nitride region; and
selectively etching the cobalt region against the cobalt silicide region stopping on the first portion of the metal nitride region using a solution comprising a mineral acid and a peroxide.

69. The method according to claim 68, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H_2SO_4, H_3PO_4, HNO_3, and dilute HF.

70. The method according to claim 69, wherein the mineral acid comprises HCl.

71. The method according to claim 68, wherein the peroxide comprises hydrogen peroxide.

72. The method according to claim 68, wherein the solution comprises a ratio in a range of about 1:1:300 (mineral acid:peroxide:deionized water) to about 1:1:70 (mineral acid:peroxide:deionized water).

73. The method according to claim 72, wherein the solution comprises a ratio in a range of about 1:1:200 (mineral acid:peroxide:deionized water) to about 1:1:100 (mineral acid:peroxide:deionized water).

74. The method according to claim 68, wherein selectively etching the cobalt region against the cobalt silicide region further comprises selectively etching the cobalt region against the cobalt silicide region at an etch rate in a range of about 50 Å/minute to about 500 Å/minute.

75. The method according to claim 68, wherein selectively etching the cobalt region against the cobalt silicide region further comprises selectively etching the cobalt region against the cobalt silicide region at an etch rate in a range of about 100 Å/minute to about 200 Å/minute.

76. (New) An etching method for use in integrated circuit fabrication, the method comprising:

providing a substrate assembly comprising a metal nitride region and a cobalt silicide region, wherein providing the substrate assembly comprises:

forming a metal nitride layer; and

forming the cobalt silicide region on at least a first portion of the metal nitride layer; and

selectively etching a portion of the metal nitride region against the cobalt silicide region using a solution comprising a peroxide, wherein the solution etches the portion of the metal nitride region at an etch rate in a range of about 50 Å/minute to about 250 Å/minute.

77. **(New)** The method according to claim 76, wherein forming the cobalt silicide region on at least the first portion of the metal nitride layer further comprises:

contacting a cobalt layer with a patterned silicon layer; and

siliciding the cobalt layer using the patterned silicon layer.

78. **(New)** The method according to claim 77, wherein contacting the cobalt layer with the patterned silicon layer further comprises:

forming the cobalt layer on the metal nitride layer;

forming a silicon layer on the cobalt layer; and

patterning the silicon layer.

79. **(New)** The method according to claim 76, wherein the solution further comprises a mineral acid.

80. **(New)** The method according to claim 79, wherein the mineral acid comprises at least one mineral acid selected from a group consisting of HCl, H_2SO_4, H_3PO_4, HNO_3, and dilute HF.

81. **(New)** The method according to claim 80, wherein the mineral acid comprises HCl.

82. **(New)** The method according to claim 79, wherein the solution comprises a ratio in a range of about 1:1:35 (mineral acid:peroxide:deionized water) to about 1:1:5 (mineral acid:peroxide:deionized water).

83. **(New)** The method according to claim 82, wherein the solution comprises a ratio in a range of about 1:1:25 (mineral acid:peroxide:deionized water) to about 1:1:10 (mineral acid:peroxide:deionized water).

84. **(New)** The method according to claim 79, wherein the solution comprises a ratio in a range of about 0.05:1:6 (mineral acid:peroxide:deionized water) to about 1:1:6 (mineral acid:peroxide:deionized water).

85. **(New)** The method according to claim 84, wherein the solution comprises a ratio in a range of about 0.1:1:6 (mineral acid: peroxide:deionized water) to about 0.5:1:6 (mineral acid:peroxide:deionized water).

86. **(New)** The method according to claim 76, wherein the peroxide comprises hydrogen peroxide.

87. **(New)** The method according to claim 76, wherein the solution comprises a ratio in a range of about 1:50 (peroxide:deionized water) to about 1:1 (peroxide:deionized water).

88. **(New)** The method according to claim 87, wherein the solution comprises a ratio in a range of about 1:10 (peroxide:deionized water) to about 1:5 (peroxide:deionized water).